All-optical fiber-optics networks
A passive star based local optical WDM network

- Unicast
- Multicast

Workstation

Passive star coupler
A wavelength routed wide-area WDM network

Access Station: contains tunable transmitters and receivers

Switch: contains photonics switch, amplifier, $\lambda$ converter
Diagram of passive optical network

Available installation topologies:
• star
• bus
• tree
Real installation topologies

- **Star**
- **Bus**
- **Tree**
Classification of single hop optical networks

- FT - FR, fixed transmitter - fixed receiver
- TT - FR, tunable transmitter - fixed receiver
- FT - TR, fixed transmitter - fixed receiver
- TT - TR, tunable transmitter, tunable receiver

Example description of network node:
- FT^iTT^j - RF^iTR^j
- CC - FT^iTT^j - FR^mTR^n

{F - fixed | T - tunable, T - transmitter | R - receiver}
CC - control-channel, information about planned connection
i - index indicates number of node transmitters/receivers
Time-slot assignment
(time multiplexing)

- 3 workstations
- 1 channel

time is divided into 3 slots repeated in a cycle

<table>
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<th>channel no.</th>
<th>t</th>
<th>t+1</th>
<th>t+2</th>
</tr>
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<tr>
<td>0</td>
<td>(1, 2)</td>
<td>(1, 3)</td>
<td>(2, 1)</td>
</tr>
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</table>
Channel assignment, time and wavelength multiplexing
(without control channel)

- 3 workstations
- 2 channels

time is divided into 3 slots repeated in a cycle

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<th>t+2</th>
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<tr>
<td>1</td>
<td>(2, 3)</td>
<td>(3, 1)</td>
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</table>
Optical-signal distribution elements - classification

- Passive star
- Passive router
- Active switch
Passive star
4 x 4

N connections
Passive router

N^2 connections
## Router - location in OSI model

<p>| | | |</p>
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<tr>
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<td>Application</td>
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<td>6</td>
<td>Presentation</td>
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<td>5</td>
<td>Session</td>
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<tr>
<td>4</td>
<td>Transport</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Network</td>
<td>Router working area</td>
</tr>
</tbody>
</table>
| 2 | Data link | Logical Link Control  
|   |   | Media Access Control |
| 1 | Physical | Bridge working area |
Active switch

4 x 4

WRS = Wavelength Routing Switch (or Wavelength Selecting Crossconnect - WSXC)
Examples of all optical LAN networks and protocols (1)


2. **Rainbow** - N. R. Dono i in. „A wavelength division multiple access network for computer communication” IEEE Journ. on Selected Areas in Communications, vol. 8, pp. 983-993


Examples of all optical LAN networks and protocols(2)


LAMBDANET

Network name: LAMBDANET
Company: Bellcore
Network type: FT - FRM

Every workstation equipped with a laser of fixed wavelength and M receivers.
Realized network parameters:
• number of nodes - 18
• transmission speed - 2 Gb/s
• range - 57.5 km

Advantages - simplicity
Disadvantages - every node has to be equipped with N sources
(integrated optoelectronics technology can solve the problem)

Lambdanet - network diagram
Rainbow

Network name: **Rainbow I (1990), Rainbow II (1996)**

Company: **IBM**

Network type: FT - TR

Network type: MAN

Every workstation is equipped in one laser of fixed wavelength and a tunable receiver.

Network parameters:

- Number of nodes - 32 IBM PS/2
- Transmission speed - 200 Mb/s
- Range - 10 - 20 km

Rainbow I: N. R. Dono i in. „A wavelength division multiple access network for computer communication” IEEE Journ. on Selected Areas in Communications, vol. 8, pp. 983-993, Aug. 1990

Rainbow network - topology

Node 1

\[ \lambda_1 \]

\[ \lambda_2 \]

\[ \lambda_3 \]

\[ \lambda_N \]

Node 2

PCS

Node 3

Node N

transmitter (Tx)

fixed

receiver (Rx)

tunable

NIU

fixed

E - Electronic interface

transmitter (Tx)

tunable

receiver (Rx)

NIU

PSC - Passive Star Coupler

NIU - Network Interface Unit

E - Electronic interface

O - Optical interface

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All-optical networks
FOX

Network name: **FOX** (Fiber Optic Crossconnect), 1986
Network type: TT - FR
Designation: Computers with parallel data processing

Tunable lasers are used as a sources. (tuning time below a few ns – packet switching)

Configuration: two passive stars, one for the data send from the processors into memory blocks, other for the data flowing in the opposite direction.
Network name: STARNET
Network type: FT - FR
Designation: WDM LAN
Notes: contains two virtual subnets

Every node contains one transmitter and two receivers (working on the same wavelengths, but with different speeds)

STARNET networks is composed of two virtual subnets:
• fast (2,5 GB/s) network with packet switching
• slower control subnet ( 125 MB/s  FDDI compatible)

Transmitters in every node generate data for both subnets. „Slow“ detector in each node is tuned to listen the previous node transmitter - this way a logical ring is created (FDDI type)
Single-hop network classification (1)

- WDM local lightwave networks
  - Single-hop
    - Arbitrary topology
        - No control signal
            - Built systems
                - LAMBDANET
                - RAINBOW
                - FOX
                - HYPASS, BHYPASS, STAR-TRACK, PLL i inne
        - With control signal
            - Proposals
            - AMTRAC (TT-FR)
                - Multichannel Probabilistic Scheduling (TT-FR)
    - Multihop
        - Linear structures (attempt-and-defer)
Experimental systems

- LAMBDANET (receiver array: FT-FR<sup>M</sup>)
- RAINBOW (in-band receiver polling: FT-TR)
- FOX (TT-FR)
- HYPASS, BHYPASS, STAR-TRACK, PLL and others

Proposals

- Fixed Assignment (TT-TR)
- Partial Fixed Assignment (TT-TR)
- Random Access Protocols I (TT-FR)
- Random Access Protocols II (TT-FR<sup>x</sup>)
- PAC nets (TT-FR)

Nets with control channel

- Partial Random Access (CC-TT-TR)
- Improved Random Access (CC-TT-TR)
- Binominal Throughput, Nonmonotonic Delay
- Extended Slotted ALOHA and Reservation ALOHA (CC-TT-TR)
- (RCA) Receiver Collision Avoidance Protocol (CC-TT-TR)
- Dynamic Time-Wavelength Division Multiple Access (DTWDMA) (CC-FT2-FRTR)
- TDMA/N-Server (CC-TT-FRTR)

_PAC - Protection Against Collision_
Summary

• The optimal solution for building an all-optical „local“ area network is a passive star topology, with single-hop connection.

• WDM technology renders possible full utilization of fiber optic bandwidth.
Literature

B. Mukherjee, Optical Communication Networks, McGraw-Hill 1997